

WHAT IS CLAIMED IS:

1. A multicast communication path
5 calculation method for obtaining multicast paths
from a given source node to a plurality of
destination nodes in a network including a plurality
of nodes, the method comprising the steps of:
obtaining minimum delay paths from the
10 source node to each of the destination nodes by
using topology information and delay information of
the network;
selecting, as candidate nodes of a
rendezvous point node, nodes on one of the obtained
15 minimum delay paths;
for each of the candidate nodes,
calculating minimum delay paths from the candidate
node to each of the destination nodes, and obtaining
a difference between the maximum value and the
20 minimum value among delays of the calculated minimum
delay paths;
selecting, as the rendezvous point node,
the candidate node for which the difference is
smallest among differences for all of the candidate
25 nodes; and
outputting, as the multicast paths, a
minimum delay path from the source node to the
rendezvous point node and minimum delay paths from
the rendezvous point node to each destination node.
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2. The multicast communication path
35 calculation method as claimed in claim 1, wherein
the minimum delay path on which the candidate nodes
exist is one having maximum delay among minimum

delay paths from the source node to each of the destination nodes.

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3. A multicast communication path setting method, wherein a multicast communication path calculation apparatus calculates multicast paths
10 from a given source node to a plurality of destination nodes in a network including a plurality of nodes, and a multicast communication path setting apparatus establishes the calculated multicast paths on the network, wherein the multicast communication
15 path setting apparatus sends a request to calculate the multicast paths to the multicast communication path calculation apparatus, and the multicast communication path calculation apparatus calculates the multicast paths according to the request by
20 using a method comprising the steps of:

obtaining minimum delay paths from the source node to each of the destination nodes by using topology information and delay information of the network;

25 selecting, as candidate nodes of a rendezvous point node, nodes on one of the obtained minimum delay paths;

for each of the candidate nodes,
calculating minimum delay paths from the candidate
30 node to each of the destination nodes, and obtaining a difference between the maximum value and the minimum value among delays of the calculated minimum delay paths;

selecting, as the rendezvous point node,
35 the candidate node for which the difference is smallest among the differences for all of the candidate nodes; and

outputting results comprising, as the
multicast paths, a minimum delay path from the
source node to the rendezvous point node and minimum
delay paths from the rendezvous point node to each
5 destination node,

wherein the multicast communication path
calculation apparatus sends the output results to
the multicast communication path setting apparatus,
and the multicast communication path setting
10 apparatus establishes the multicast paths according
to the output results.

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4. The multicast communication path
setting method as claimed in claim 3, wherein each
node in the network measures traffic state of the
network and sends the measurement results to the
20 multicast communication path calculation apparatus,
and

the multicast communication path
calculation apparatus calculates the multicast paths
according to the measurement results.
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5. A multicast communication path
30 calculation apparatus for obtaining multicast paths
from a given source node to a plurality of
destination nodes in a network including a plurality
of nodes, the apparatus comprising:

a part for obtaining minimum delay paths
35 from the source node to each of the destination
nodes by using topology information and delay
information of the network;

a part for selecting, as candidate nodes of a rendezvous point node, nodes on one of the obtained minimum delay paths;

5 a part for calculating, for each of the candidate nodes, minimum delay paths from the candidate node to each of the destination nodes, and obtaining, for each of the candidate nodes, a difference between the maximum value and the minimum value among delays of the calculated minimum delay
10 paths;

a part for selecting, as the rendezvous point node, the candidate node for which the difference is smallest among the differences for all of the candidate nodes; and

15 a part for outputting results comprising, as the multicast paths, a minimum delay path from the source node to the rendezvous point node and minimum delay paths from the rendezvous point node to each of the destination nodes.

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6. The multicast communication path
25 calculation apparatus as claimed in claim 5, wherein the minimum delay path on which the candidate nodes exist is one having maximum delay among minimum delay paths from the source node to each of the destination nodes.

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7. The multicast communication path
35 calculation apparatus as claimed in claim 5, further comprising:

a part for receiving the topology

information and the delay information of the network; and

a part for storing the received information in a recording medium,

5 wherein the multicast communication path calculation apparatus calculates the multicast paths by reading the received information from the recording medium.

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8. The multicast communication path calculation apparatus as claimed in claim 5, further
15 comprising a part for including the output results in a multicast path setting control message, and sending the multicast path setting control message over the multicast paths indicated by the output results.

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9. The multicast communication path calculation apparatus as claimed in claim 5, further
25 comprising:

a part for receiving a request to calculate the multicast paths from a multicast communication path setting apparatus; and

30 a part for sending the output results to the multicast communication path setting apparatus.

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10. A computer program for causing a multicast communication path calculation apparatus

to calculate multicast paths from a given source node to a plurality of destination nodes in a network including a plurality of nodes, the computer program comprising:

- 5 program code means for obtaining minimum delay paths from the source node to each of the destination nodes by using topology information and delay information of the network;
- program code means for selecting, as
10 candidate nodes of a rendezvous point node, nodes on one of the obtained minimum delay paths;
- program code means for calculating, for each of the candidate nodes, minimum delay paths from the candidate node to each of the destination
15 nodes, and obtaining, for each of the candidate nodes, a difference between the maximum value and the minimum value among delays of the calculated minimum delay paths;
- program code means for selecting, as the
20 rendezvous point node, the candidate node for which the difference is smallest among the differences for each of the candidate nodes; and
- program code means for outputting results comprising, as the multicast paths, a minimum delay
25 path from the source node to the rendezvous point node and minimum delay paths from the rendezvous point node to each of the destination nodes.

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11. The computer program as claimed in claim 10, wherein the minimum delay path on which the candidate nodes exist is one having maximum
35 delay among minimum delay paths from the source node to each of the destination nodes.

12. A computer readable medium storing
5 program code for causing a multicast communication
path calculation apparatus to calculate multicast
paths from a given source node to a plurality of
destination nodes in a network including a plurality
of nodes, the computer readable medium comprising:
10 program code means for obtaining minimum
delay paths from the source node to each of the
destination nodes by using topology information and
delay information of the network;
program code means for selecting, as
15 candidate nodes of a rendezvous point node, nodes on
one of the obtained minimum delay paths;
program code means for calculating, for
each of the candidate nodes, minimum delay paths
from the candidate node to each of the destination
20 nodes, and obtaining, for each of the candidate
nodes, a difference between the maximum value and
the minimum value among delays of the calculated
minimum delay paths;
program code means for selecting, as the
25 rendezvous point node, the candidate node for which
the difference is smallest among the differences for
all of the candidate nodes; and
program code means for outputting results
comprising, as the multicast paths, a minimum delay
30 path from the source node to the rendezvous point
node and minimum delay paths from the rendezvous
point node to each of the destination nodes.

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13. The computer readable medium as

claimed in claim 12, wherein the minimum delay path on which the candidate nodes exist is one having maximum delay among minimum delay paths from the source node to each of the destination nodes.

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14. A multicast communication path
10 calculation method for obtaining multicast paths from a given source node to a plurality of destination nodes in a network including a plurality of nodes, the method comprising the steps of:
receiving a distance graph including
15 topology and cost of the network;
establishing a first distance subgraph in which the source node is deleted from the received distance graph;
selecting the destination nodes from the
20 first distance subgraph, obtaining a second distance subgraph in which each edge is a shortest path between two of the destination nodes, and establishing a first minimal spanning tree of the second distance subgraph;
25 establishing a subgraph of the first minimal spanning tree by including intermediate nodes in each of the edges of the first minimal spanning tree, and establishing a second minimal spanning tree of the subgraph;
30 deleting unnecessary edges from the second minimal spanning tree so that a tree including the destination nodes is established;
assuming that nodes that form the tree are candidate nodes of a rendezvous point node,
35 obtaining, for each of the candidate nodes, a difference between the maximum distance and the minimum distance among distances between the

candidate node and each of the destination nodes,
and selecting, as the rendezvous point node, the
candidate node for which the difference is smallest;
and

5 obtaining the multicast paths by
connecting the tree and the source node at the
rendezvous point node, and outputting the multicast
paths.

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15 15. A multicast communication path setting
method, wherein a multicast communication path
calculation apparatus calculates multicast paths
from a given source node to a plurality of
destination nodes in a network including a plurality
of nodes, and a multicast communication path setting
apparatus establishes the calculated multicast paths
20 on the network, wherein the multicast communication
path setting apparatus sends a request to calculate
the multicast paths to the multicast communication
path calculation apparatus, and the multicast
communication path calculation apparatus calculates
25 the multicast paths according to the request by
using a method comprising the steps of:

 reading a distance graph including
topology and cost of the network;

 establishing a first distance subgraph in
30 which the source node is deleted from the received
distance graph;

 selecting the destination nodes from the
first distance subgraph, obtaining a second distance
subgraph in which each edge is a shortest path
35 between two of the destination nodes, and
establishing a first minimal spanning tree of the
second distance subgraph;

establishing a subgraph of the first
minimal spanning tree by including intermediate
nodes in each of the edges of the first minimal
spanning tree, and establishing a second minimal
5 spanning tree of the subgraph;

deleting unnecessary edges from the second
minimal spanning tree so that a tree including the
destination nodes is established;

assuming that nodes that form the tree are
10 candidate nodes of a rendezvous point node,
obtaining, for each of the candidate nodes, a
difference between the maximum distance and the
minimum distance among distances between the
candidate node and each of the destination nodes,
15 and selecting, as the rendezvous point node, the
candidate node for which the difference is smallest;
and

obtaining the multicast paths by
connecting the tree and the source node at the
20 rendezvous point node, and outputting results
comprising the multicast paths,

wherein the multicast communication path
calculation apparatus sends the output results to
the multicast communication path setting apparatus,
25 and the multicast communication path setting
apparatus establishes the multicast paths according
to the output results.

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16. The multicast communication path
setting method as claimed in claim 15, wherein each
of the nodes in the network measures traffic state
35 of the network and sends the measurement results to
the multicast communication path calculation
apparatus, and

the multicast communication path calculation apparatus calculates the multicast paths according to the measurement results.

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17. A multicast communication path calculation apparatus for obtaining multicast paths from a given source node to a plurality of destination nodes in a network including a plurality of nodes, the apparatus comprising:

10 a part for receiving a distance graph including topology and cost of the network;

15 a part for establishing a first distance subgraph in which the source node is deleted from the received distance graph;

a part for selecting the destination nodes from the first distance subgraph, obtaining a second distance subgraph in which each edge is a shortest path between two of the destination nodes, and establishing a first minimal spanning tree of the second distance subgraph;

20 a part for establishing a subgraph of the first minimal spanning tree by including intermediate nodes in each of the edges of the first minimal spanning tree, and establishing a second minimal spanning tree of the subgraph;

25 a part for deleting unnecessary edges from the second minimal spanning tree so that a tree including the destination nodes is established;

30 a part for, assuming that nodes that form the tree are candidate nodes of a rendezvous point node, obtaining, for each of the candidate nodes, a difference between the maximum distance and the minimum distance among distances between the candidate node and each of the destination nodes,

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and selecting, as the rendezvous point node, the candidate node for which the difference is smallest; and

5 a part for obtaining the multicast paths by connecting the tree and the source node at the rendezvous point node, and outputting results comprising the multicast paths.

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18. The multicast communication path calculation apparatus as claimed in claim 17, further comprising:

15 a part for receiving the topology information and the delay information of the network; and

a part for storing the received information in a recording medium,

20 wherein the multicast communication path calculation apparatus calculates the multicast paths by reading the received information from the recording medium.

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19. The multicast communication path calculation apparatus as claimed in claim 17, further comprising a part for including the output results in a multicast path setting control message, and sending the multicast path setting control message over the multicast paths indicated by the output results.

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20. The multicast communication path calculation apparatus as claimed in claim 17, further comprising:

- 5 a part for receiving a request to calculate the multicast paths from a multicast communication path setting apparatus; and
- a part for sending the output results to the multicast communication path setting apparatus.

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21. A computer program for causing a
15 multicast communication path calculation apparatus to calculate multicast paths from a given source node to a plurality of destination nodes in a network including a plurality of nodes, the computer program comprising:

- 20 program code means for receiving a distance graph including topology and cost of the network;

 program code means for establishing a first distance subgraph in which the source node is
25 deleted from the received distance graph;

 program code means for selecting the destination nodes from the first distance subgraph, obtaining a second distance subgraph in which each edge is a shortest path between two of the
30 destination nodes, and establishing a first minimal spanning tree of the second distance subgraph;

 program code means for establishing a subgraph of the first minimal spanning tree by including intermediate nodes in each of the edges of
35 the first minimal spanning tree, and establishing a second minimal spanning tree of the subgraph;

 program code means for deleting

unnecessary edges from the second minimal spanning tree so that a tree including the destination nodes is established;

5 program code means for, assuming that
nodes that form the tree are candidate nodes of a
rendezvous point node, obtaining, for each of the
candidate nodes, a difference between the maximum
distance and the minimum distance among distances
between the candidate node and each of the
10 destination nodes, and selecting, as the rendezvous
point node, the candidate node for which the
difference is smallest; and

 program code means for obtaining the
multicast paths by connecting the tree and the
15 source node at the rendezvous point node, and
outputting the multicast paths.

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 22. A computer readable medium storing
program code for causing a multicast communication
path calculation apparatus to calculate multicast
paths from a given source node to a plurality of
25 destination nodes in a network including a plurality
of nodes, the computer readable medium comprising:

 program code means for receiving a
distance graph including topology and cost of the
network;

30 program code means for establishing a
first distance subgraph in which the source node is
deleted from the received distance graph;

 program code means for selecting the
destination nodes from the first distance subgraph,
35 and obtaining a second distance subgraph in which
each edge is a shortest path between two of the
destination nodes, and establishing a first minimal

spanning tree of the second distance subgraph;

program code means for establishing a
subgraph of the first minimal spanning tree by
including intermediate nodes in each of the edges of
5 the first minimal spanning tree, and establishing a
second minimal spanning tree of the subgraph;

program code means for deleting
unnecessary edges from the second minimal spanning
tree so that a tree including the destination nodes
10 is established;

program code means for, assuming that
nodes that form the tree are candidate nodes of a
rendezvous point node, obtaining, for each of the
candidate nodes, a difference between the maximum
15 distance and the minimum distance among distances
between the candidate node and each of the
destination nodes, and selecting, as the rendezvous
point node, the candidate node for which the
difference is smallest; and

20 program code means for obtaining the
multicast paths by connecting the tree and the
source node at the rendezvous point node, and
outputting the multicast paths.

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